

Transfer of Probabilistic Winter Weather Products from WPC Test Bed to Operations



**Weather Prediction Center – Hydrometeorology
Test Bed**

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Presentation Outline

- **Winter Weather Experiment 2015**
 - R2O Deliverables
- **Winter Weather Experiment 2016**
 - New Science and Findings
- **Long-Term Forecast Experiment FY2017**
 - A Look Ahead

WPC Hydrometeorology Testbed

2015 Winter Weather Forecasting Experiment

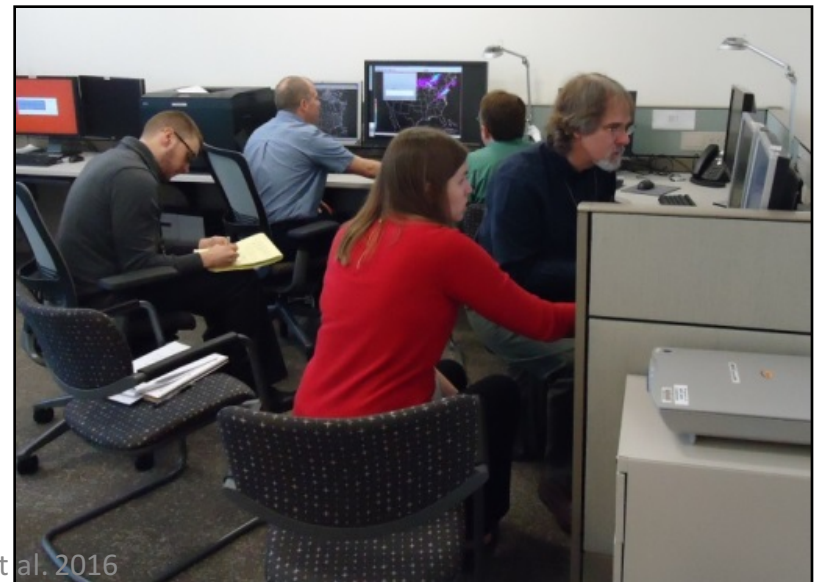
SCIENCE GOALS

Explore the value of model implicit snowfall methods using microphysics-based parameters (rime factor, % frozen precipitation) and snow water equivalent from the model

Test new datasets and thresholds for experimental
Day 4-7 Winter Weather Outlook

METHOD

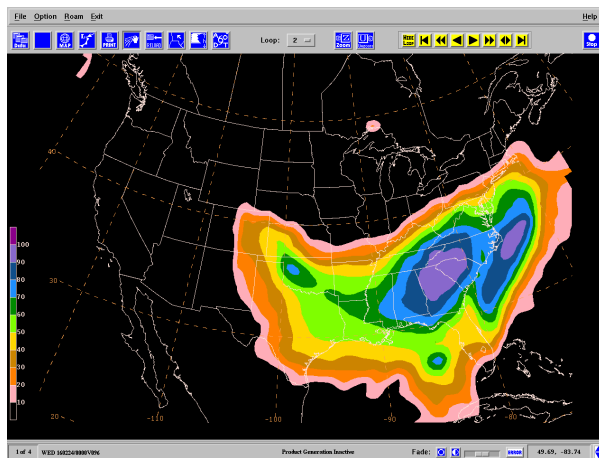
Assembly of forecasters, developers, & academics evaluated operational and experimental tools for winter weather events in real-time, pseudo-operational environment



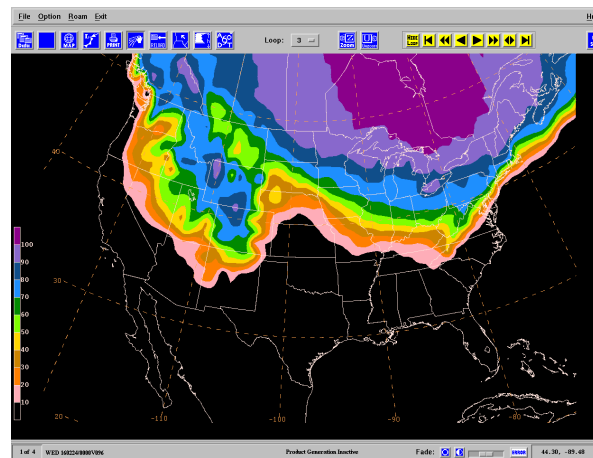
Day 4-7 Winter Weather PQPF

- **Generation of WPC Guidance**

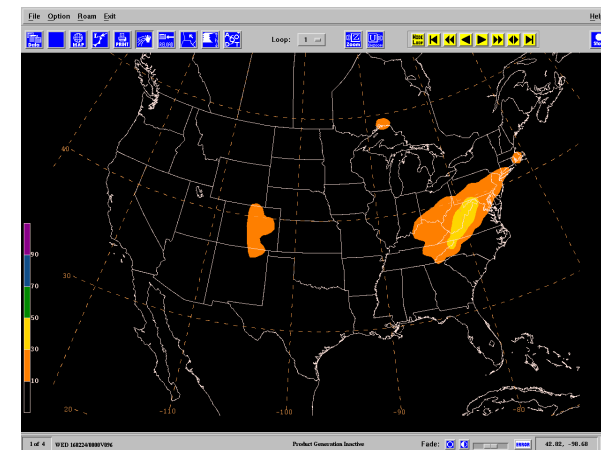
- Disaggregate WPC Day 4-5 & Day 6-7 QPF into 24 hour QPF (Mean)
- Use GEFS, ECENS & CMCE (Variance) to generate CDF to extract QPF probabilities
- Apply basic p-type algorithm to each ensemble member to construct ensemble p-type probabilities
- Combine QPF probabilities and ensemble probability of p-type



Prob of WPC QPF $\geq 0.25''$

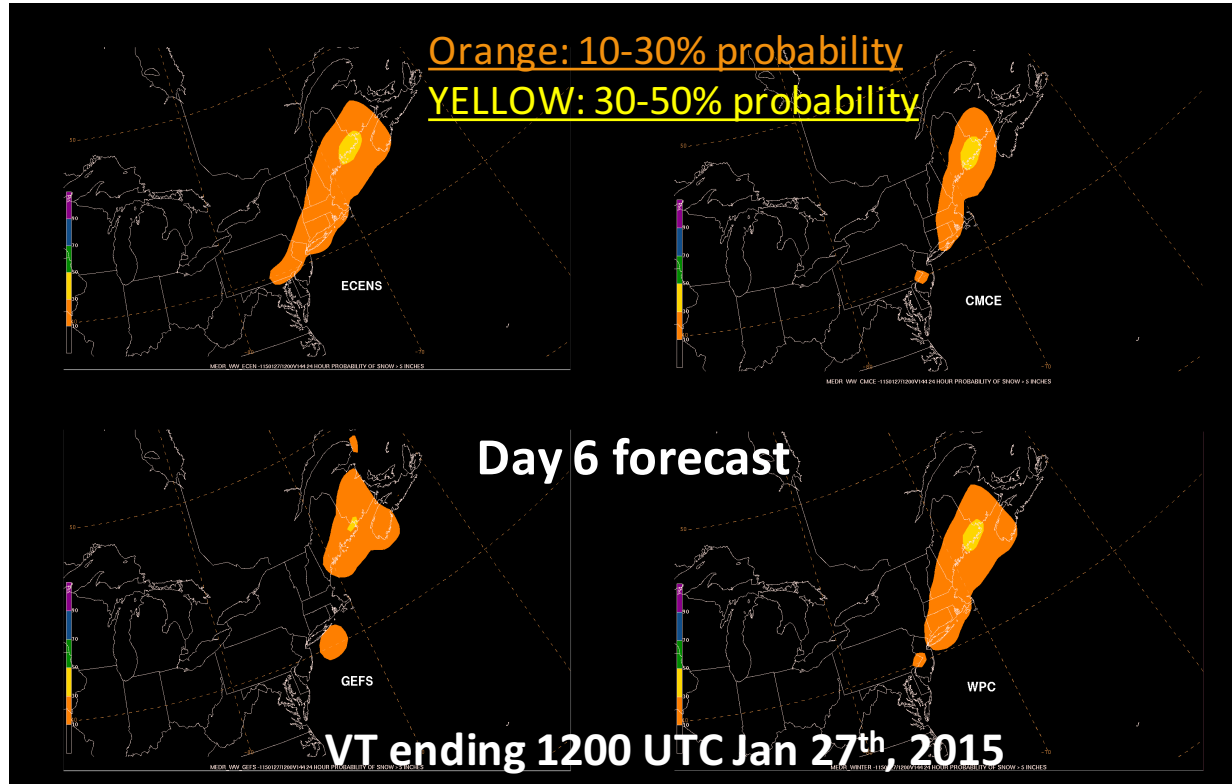


Ensemble Prob of Snow



Joint Prob of Melted Snow $> 0.25''$

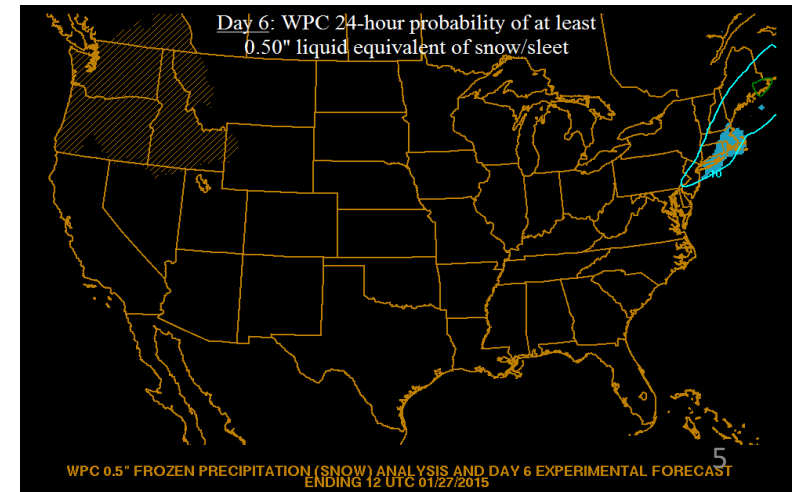
Forecast Exercise - New England Blizzard



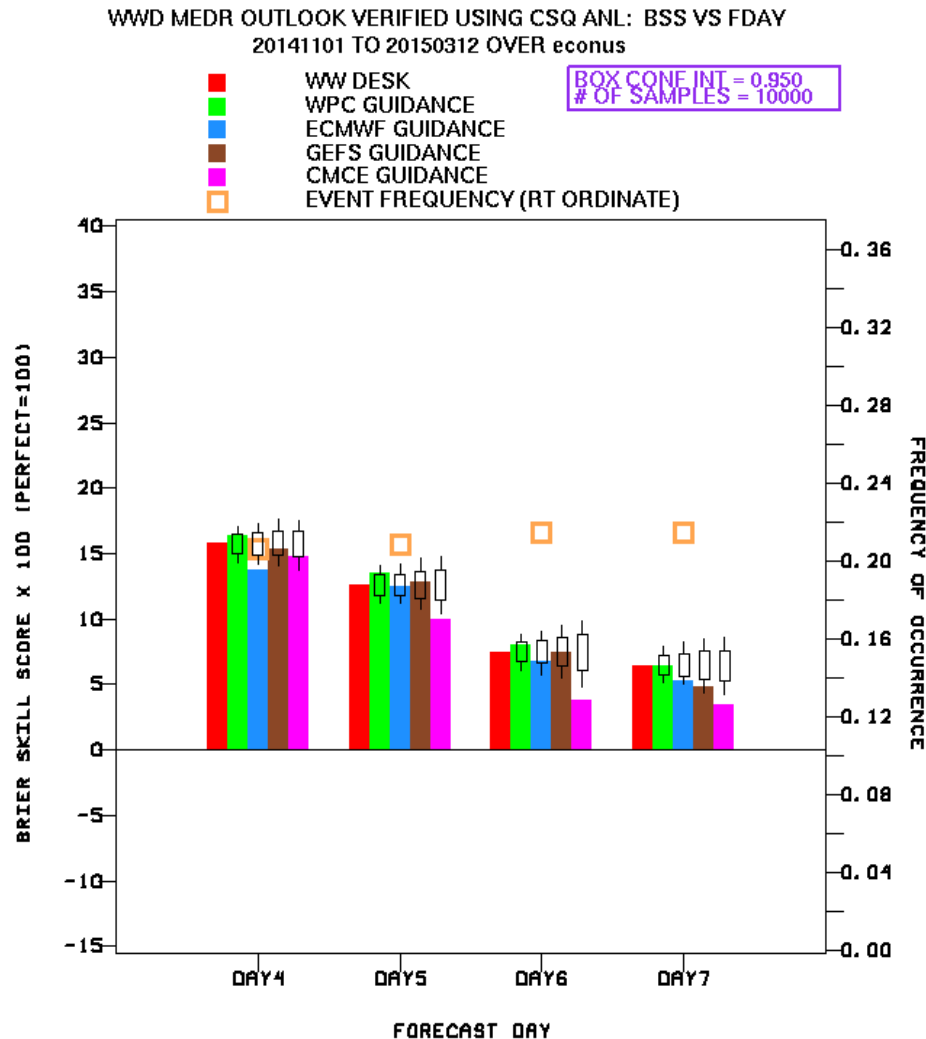
**WWE Day 6 FCST
Exercise:
Heavy Snowfall**

24-hour probability of Melted Snow > 0.5"

WWE Forecast and Visual Verification →



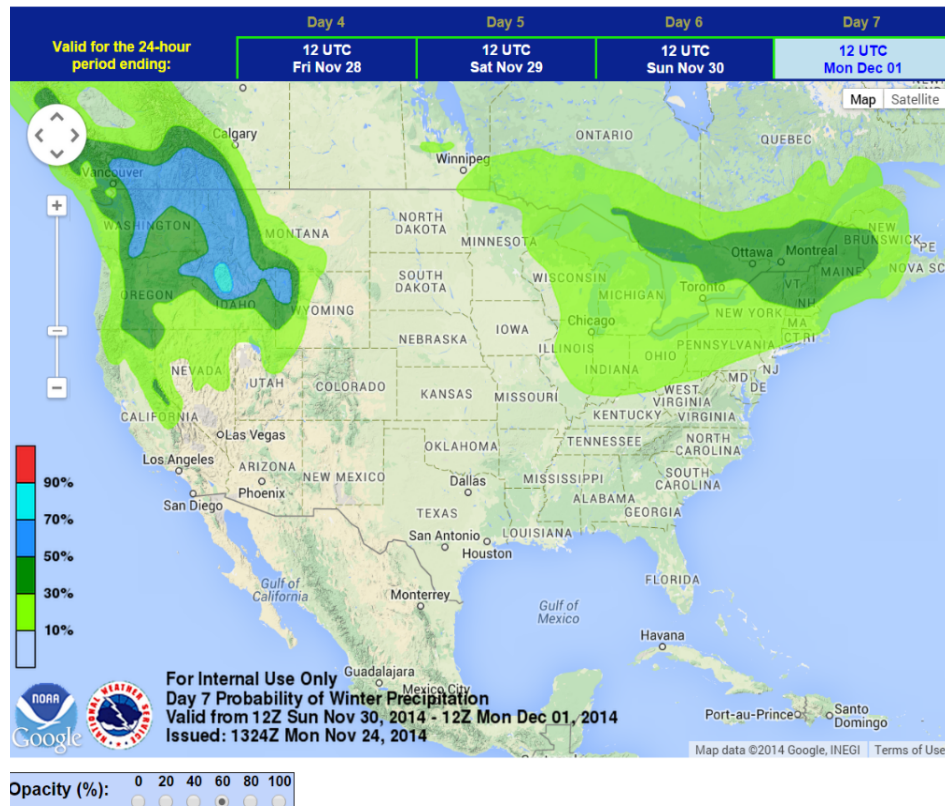
Day 4-7 Winter Weather PQPF: Objective and Visual Verification from 2014-15



- Skill noted for all forecast days
- The upgraded guidance from GEFS QPF to multi-ensemble QPF, and from dominant p-type to algorithmic p-type data resulted in improvements from 2013-14 season
- Blended ensemble system was best forecast
- Human forecast adds value by adjusting for higher terrain, and identifying more significant events

Day 4-7 Winter Weather PQPF: Changes for 2015-16 (based on 2015 WWE & WFO Feedback)

2014-15: Disseminated to WFOs

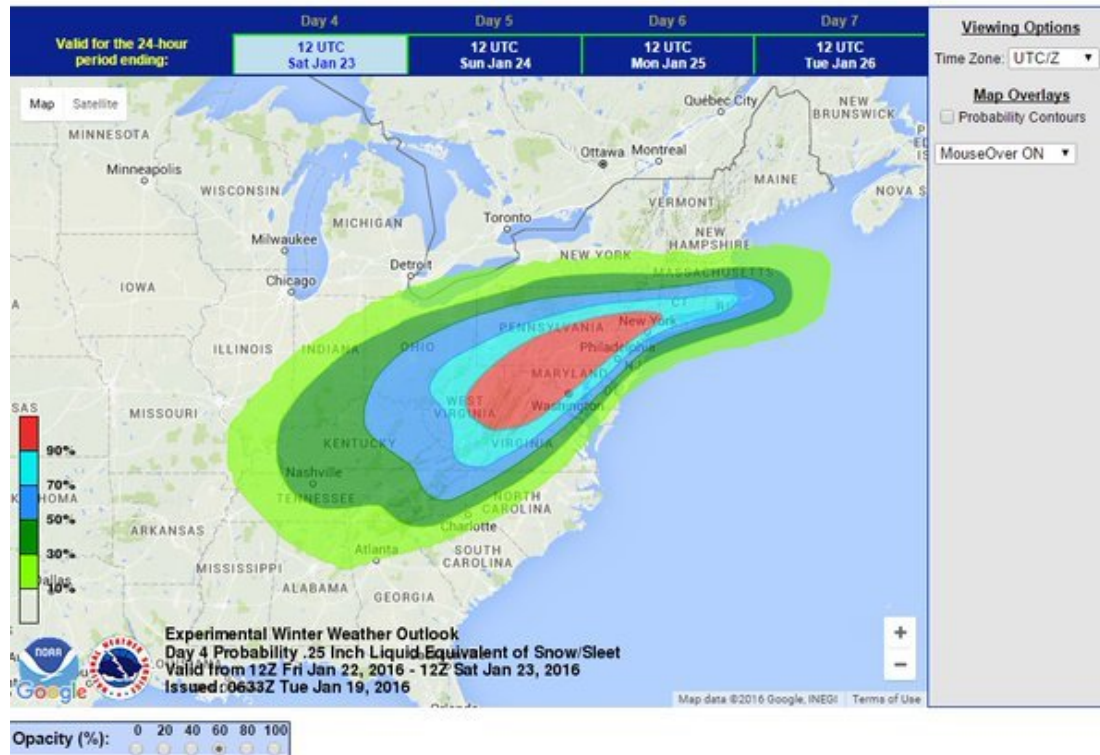


- Externally issued product switched :

Probability of winter precipitation (SN/IP/ZR) exceeding 0.10" to
Probability of snow and sleet exceeding 0.25"
- 0.05" freezing rain threshold issued internally at WPC during 2015-16
- Added WPC downscaled QPF to guidance computation

Day 4-7 Winter Weather PQPF: 2015-16 Public Evaluation

1 Dec 2015: Disseminated to Public



- Overall positive feedback on product format and user interface
- More threshold categories requested in addition to 0.25" of melted snowfall
- Wide spectrum of sophistication among users – some found information easy to interpret, others found it too technical
- Several suggestions to send out text discussion to go along with forecast maps

Other R2O Actions from WWE 2015:

Snow-liquid Ratio (SLR) Blending

Based on performance of rime factor modified SLRs during experiments in 2015 and 2014, the WPC SLR blend was changed for 2015-16

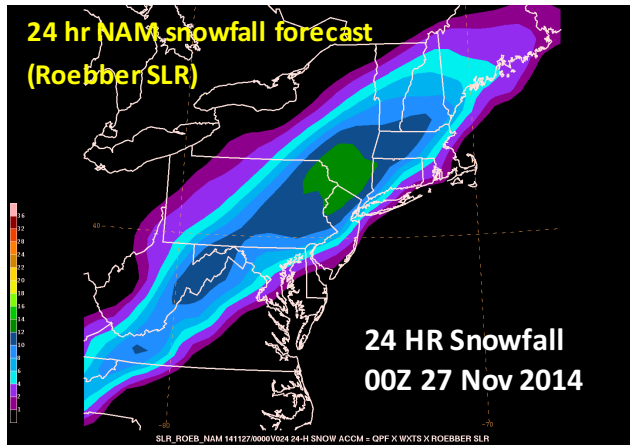
Previous Method:

NAM Roebber + GFS Roebber + Baxter Climatology + 11:1

New for 2015-16:

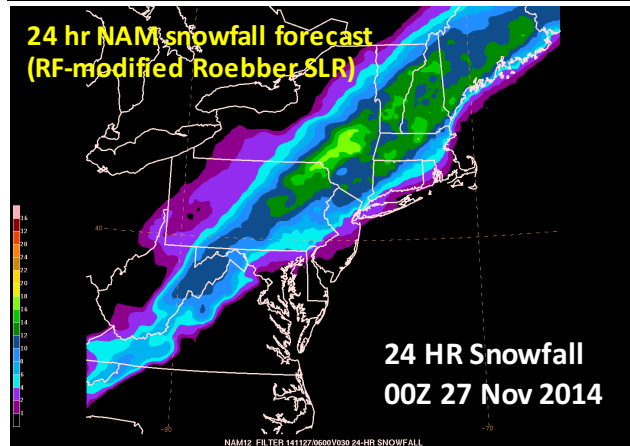
***NAM Rime Factor Roebber + NAM Rime Factor Baxter Climatology
+ GFS Roebber + Baxter Climatology + 11:1***

Sample Application of Rime Factor Modified SLR snowfall



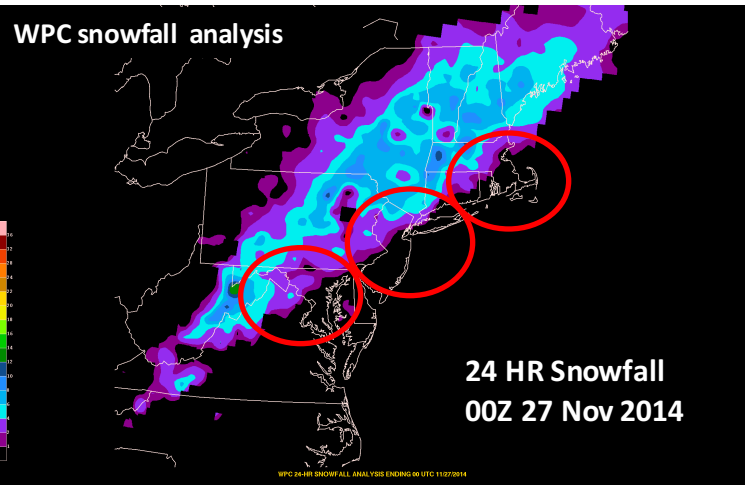
24 hr snowfall forecast (*Roebber SLR*):

- Washington D.C. ~4-6"
- New York City ~6-8"
- Philadelphia ~6-8"
- Boston ~3-6"



24 hr snowfall forecast (*RF-modified Roebber SLR*):

- Washington D.C. <1"
- New York City ~2-4"
- Philadelphia ~1-3"
- Boston ~3-6"



Application of rime factor and fraction of frozen precipitation.

WPC snowfall analysis:

Major cities received 0-1" of snow

WPC Hydrometeorology Testbed

2016 Winter Weather Forecasting Experiment

SCIENCE GOALS

Explore utility of using high-resolution convection-allowing models (CAMs) in the prediction of convective mesoscale snow banding

Explore utility of issuing probabilistic 1-hour snowfall rate forecasts using the HRRRx and HRRRx Time-Lagged Ensemble (ESRL), and the beta 3km NAM (EMC)

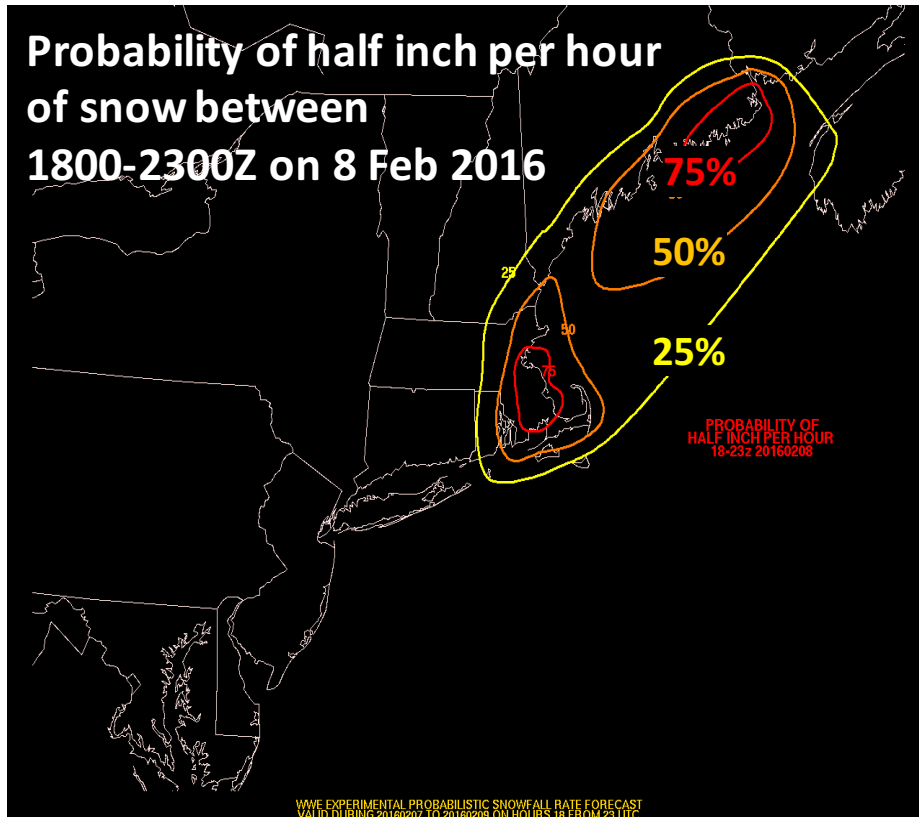
Evaluate the WPC Watch Collaborator tool

METHOD

Forecasters, developers, and academics participated in preparing experimental forecasts of probabilistic 1-hour snowfall rates, and extensive visual evaluation of forecasts and test data sets

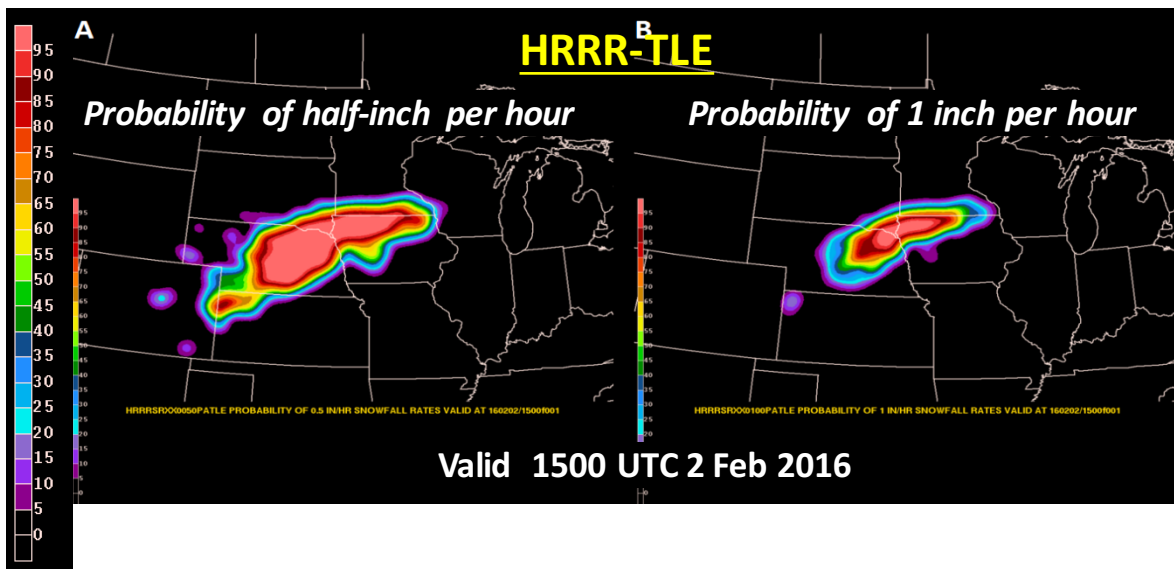


Probabilistic One-Hour Snowfall Rate Exercise



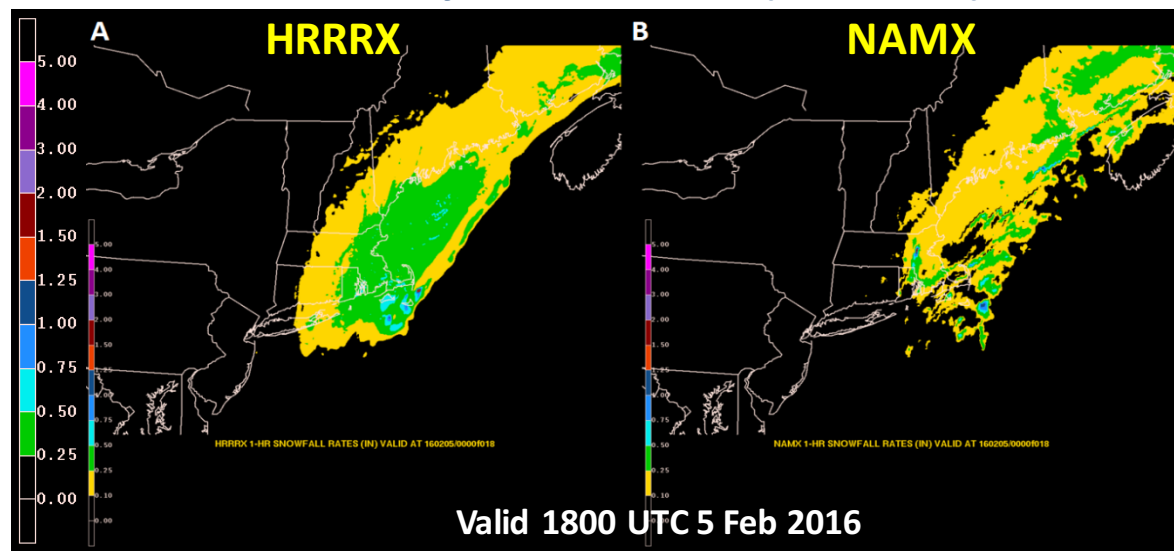
- Each day, participants produced a probabilistic snowfall rate forecast, depicting 25, 50, and 75% probabilities, of snow reaching or exceeding either 0.5, 1.0, or 2 inches per hour
- Participants specified a time range during which heavy snowfall was most likely to occur

Experimental Guidance for One-Hour Snowfall Forecasts



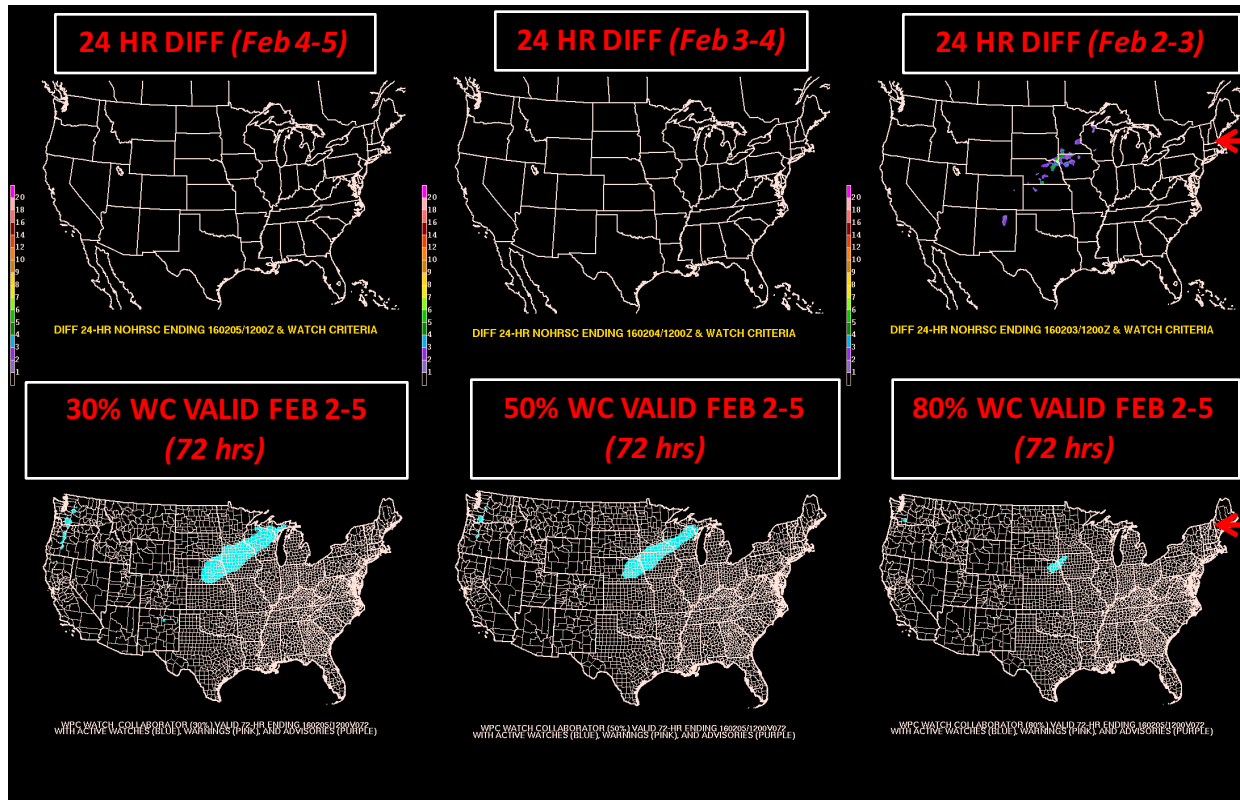
- HRRR-TLE probabilities frequently on low side in magnitude
- Areal extent of data often correct
- Difficulty handling lake effect events

Hourly snowfall rates (inches/hr)



- Snowfall Rates
= PRATE*POFP*10:1 SLR
- HRRRX and NAMX rates often too light in intensity
- Often under forecast around Great Lakes (using climatological SLR improved forecast last 2 weeks of WWE)
- *Overall positive feedback on both tools*

Evaluation of the WPC Watch Collaborator (WC)

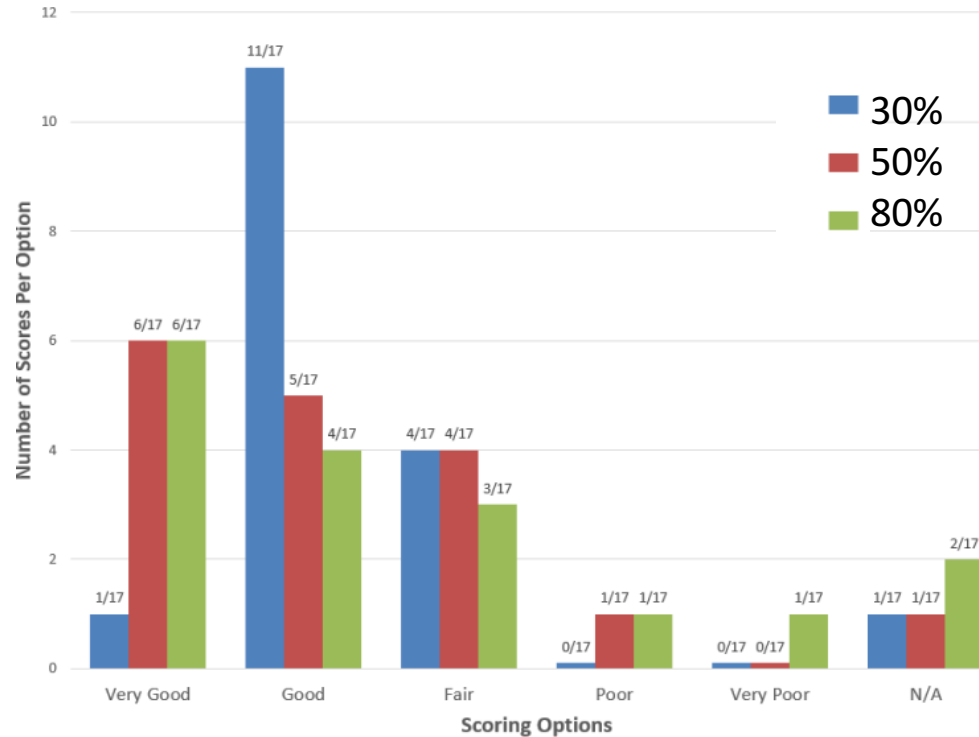


- Difference between NOHRSC snowfall analysis and 24-hr WFO winter watch threshold criteria *

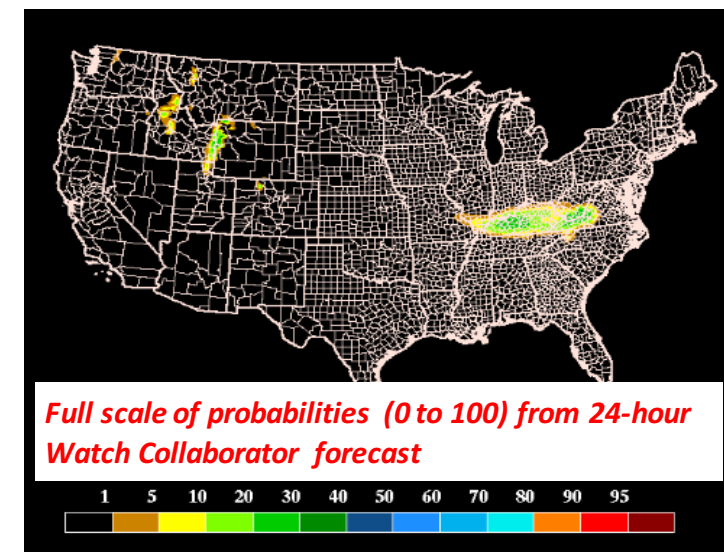
- The WC was rated for the utility of its 30%, 50% and 80% probability forecasts meeting and/or exceeding the existing WFO 24-hour criteria for issuing winter weather watches

Watch Collaborator: Visual Verification Results

Subjective Scores: Watch Collaborator Probabilities



Average subjective ratings for each Watch Collaborator probability forecast of meeting or exceeding WFO Winter Watch Criteria. Probabilities rated on a scale of 1 (Very Poor) to 5 (Very Good)



- Forecasters unanimously requested all WC probabilities (above), rather than the limited 30% and 50% probabilities currently provided.
- Participants also noted that the WPC PWPF has higher utility than the WC, and that *forecast trends* for both the PWPF and the WC would be preferable.
- Also, there were suggestions to upgrade the WC to include joint probabilities for wind and snowfall rates.

What's Next After WWE 2016?

- Hourly snowfall rates were well reviewed, and data sets will be made available to field
- Ensemble probabilities of one-hour snowfall rates need further development (i.e., more high resolution models as members)
- Watch Collaborator will be changed to include a full array of probabilities (10-100%)
- Joint probabilities highlighting multi-faceted winter weather impacts will be developed

WPC Hydrometeorology Testbed

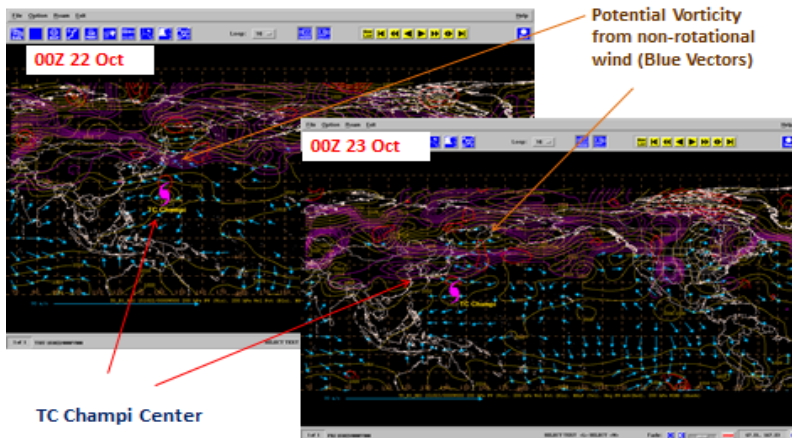
Long-Term Forecast Experiment FY2017 – Early Planning

SCIENCE GOALS

Explore various methods to make forecasts in the Day 8-10 lead time

Test tools for forecasting extreme events in the Day 8-10 period

TC “Champi” Recurvature



METHOD

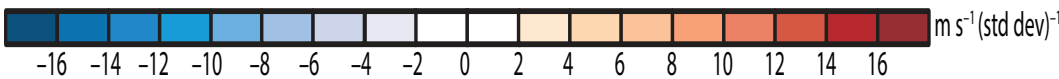
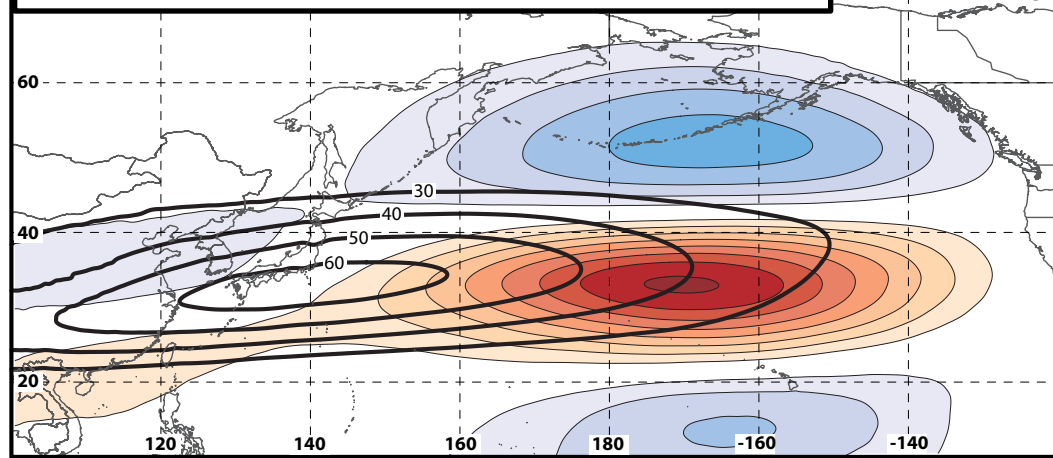
Partner with University of Albany to develop a probability based tool for use in extreme event identification.

Also, with Albany, develop a principle component (EOF) based tool to assess zonal and meridional upper tropospheric jet displacements, and review these changes on a phase space depiction to help forecast **large scale pattern changes** and **potential extreme events**.

Collaborate with WPC and CPC forecasters to test the new tools twice monthly in an experiment setting

Evaluation of 250-hPa Jet Displacements Using EOF Analysis

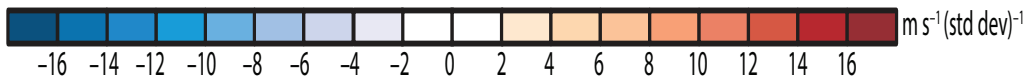
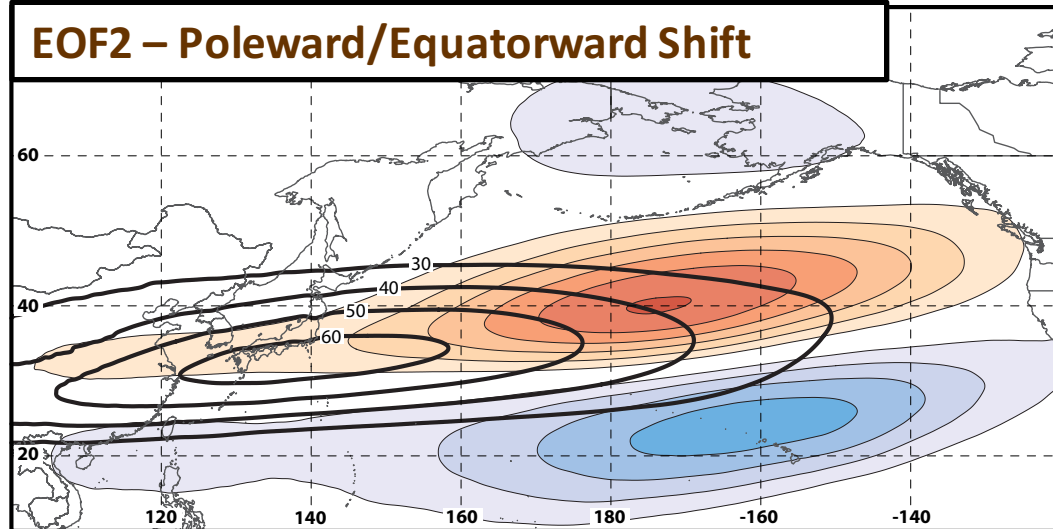
EOF1 – Jet Extension/Retraction



+ EOF1: Jet Extension
– EOF1: Jet Retraction

NDJFM Mean 250-hPa Zonal
Wind: black contours

EOF2 – Poleward/Equatorward Shift

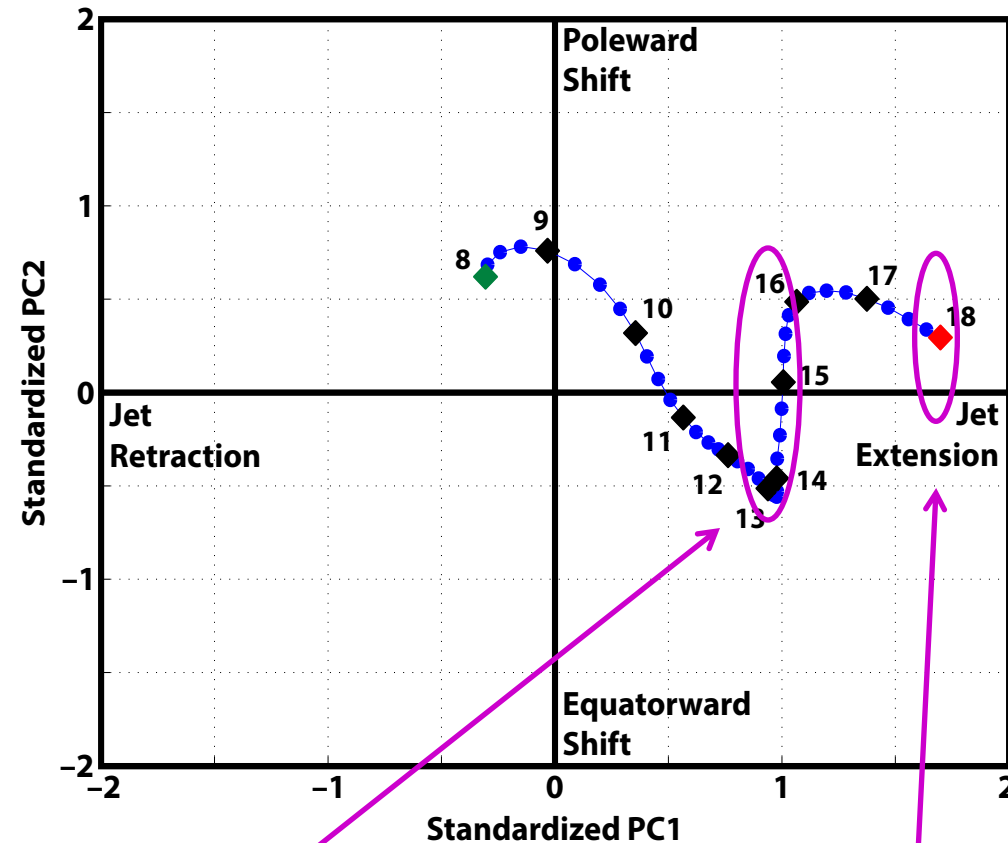


+ EOF2: Poleward Shift
– EOF2: Equatorward Shift

Phase Space Depiction Tool

U.S. Record Cold Nov 2014

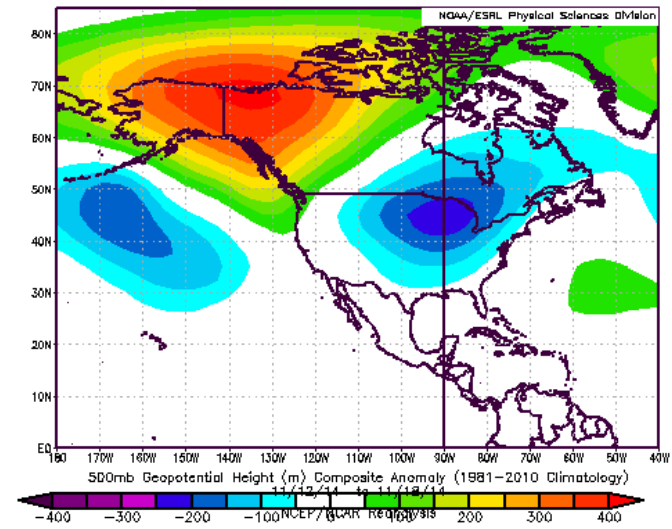
Forecast Trajectory



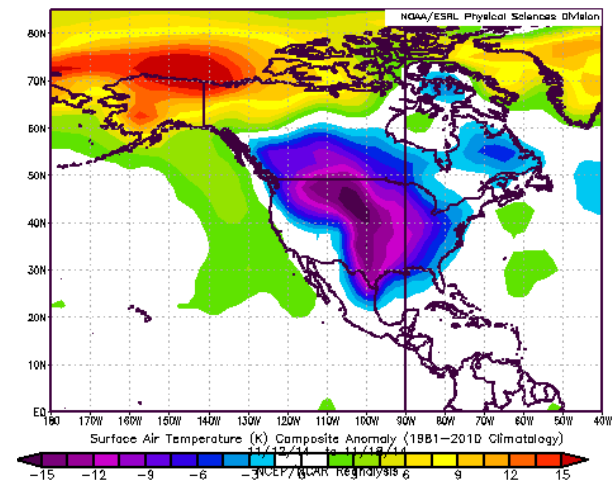
Peak Amplification
of Pattern

Record Buffalo
Snow Event

500-hPa Geo. Height (m)

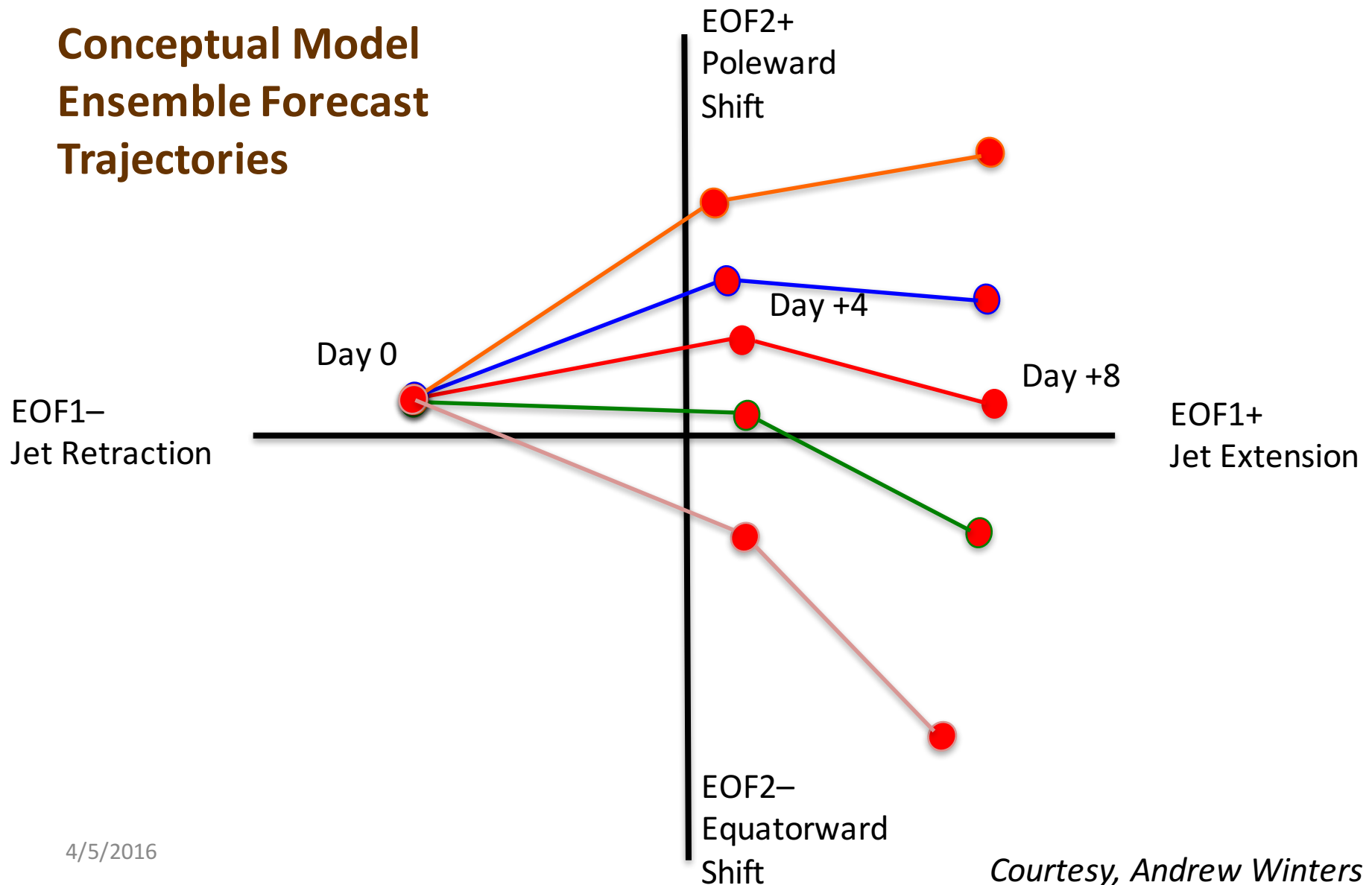


Surface Temperature (°C)



Phase Space Using Multi-Model or Ensemble Approach

**Conceptual Model
Ensemble Forecast
Trajectories**



Summary

- **Winter Weather Experiment 2015**
 - Two R2O products delivered
- **Winter Weather Experiment 2016**
 - Two probabilistic products tested – improvements will be made
- **Long-Term Forecast Experiment FY2017**
 - Ensemble forecast product in development with NGGPS partner – U of Albany

Appendix

Extreme Weather Events Identified

Temperature

Eastern US (**1st % Cold**):

- Threshold: 189 grid points ($\sim 151,000 \text{ km}^2$ or $\sim 3.5^\circ \times 3.5^\circ$ box)
- Before QC: 262 events

Eastern US (**99th % Warm**):

- Threshold: 205 grid points ($\sim 162,000 \text{ km}^2$ or $\sim 3.75^\circ \times 3.75^\circ$ box)
- Before QC: 331 events

Precipitation

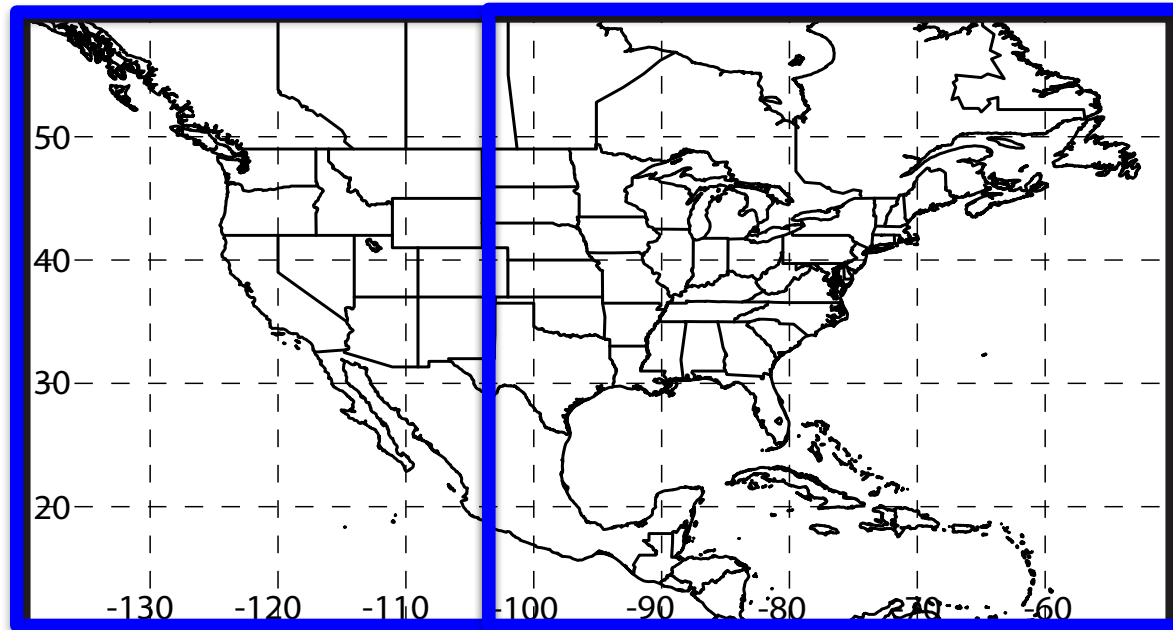
Eastern US (**99th %**):

- Threshold: 211 grid points ($\sim 162,000 \text{ km}^2$ or $\sim 3.75^\circ \times 3.75^\circ$ box)
- After QC: 351 events

Western US (**99th %**):

- Threshold: 141 grid points ($\sim 111,000 \text{ km}^2$ or $\sim 3^\circ \times 3^\circ$ box)
- After QC: 333 events

Proposed Grid Domains – First Cut

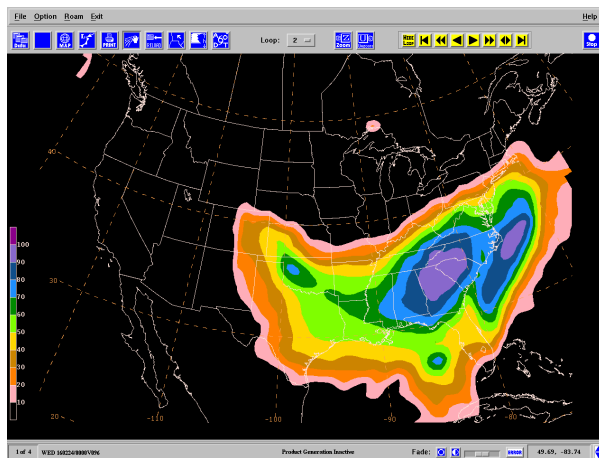


*Courtesy,
Andrew Winters*

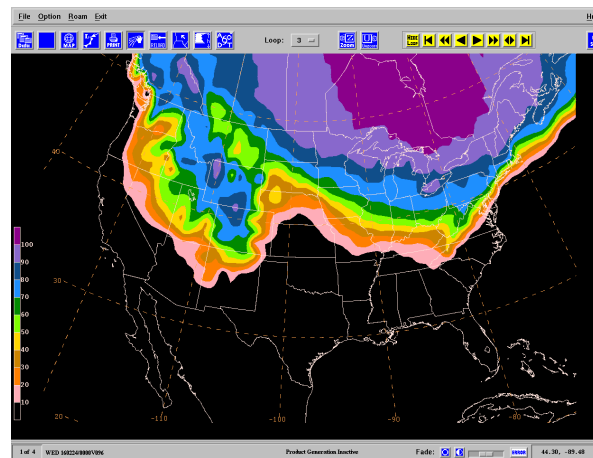
Day 4-7 Winter Weather PQPF

- **Generation of WPC Guidance**

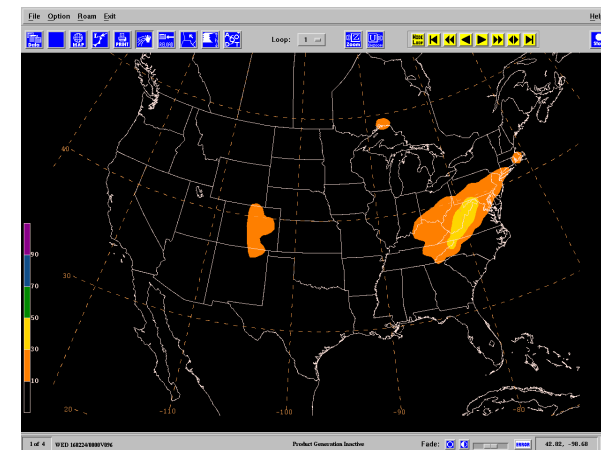
- Disaggregate WPC Day 4-5 & Day 6-7 QPF into 6 hour QPF
 - Use ensemble means to determine percentages of 48 QPF attributed to each 6 hour time period
- Use GEFS, ECENS & CMCE to generate CDF to extract QPF probabilities
- Apply basic p-type algorithm to each ensemble member to construct ensemble p-type probabilities
- Combine QPF probabilities and ensemble probability of p-type



Prob of WPC QPF $\geq 0.25''$

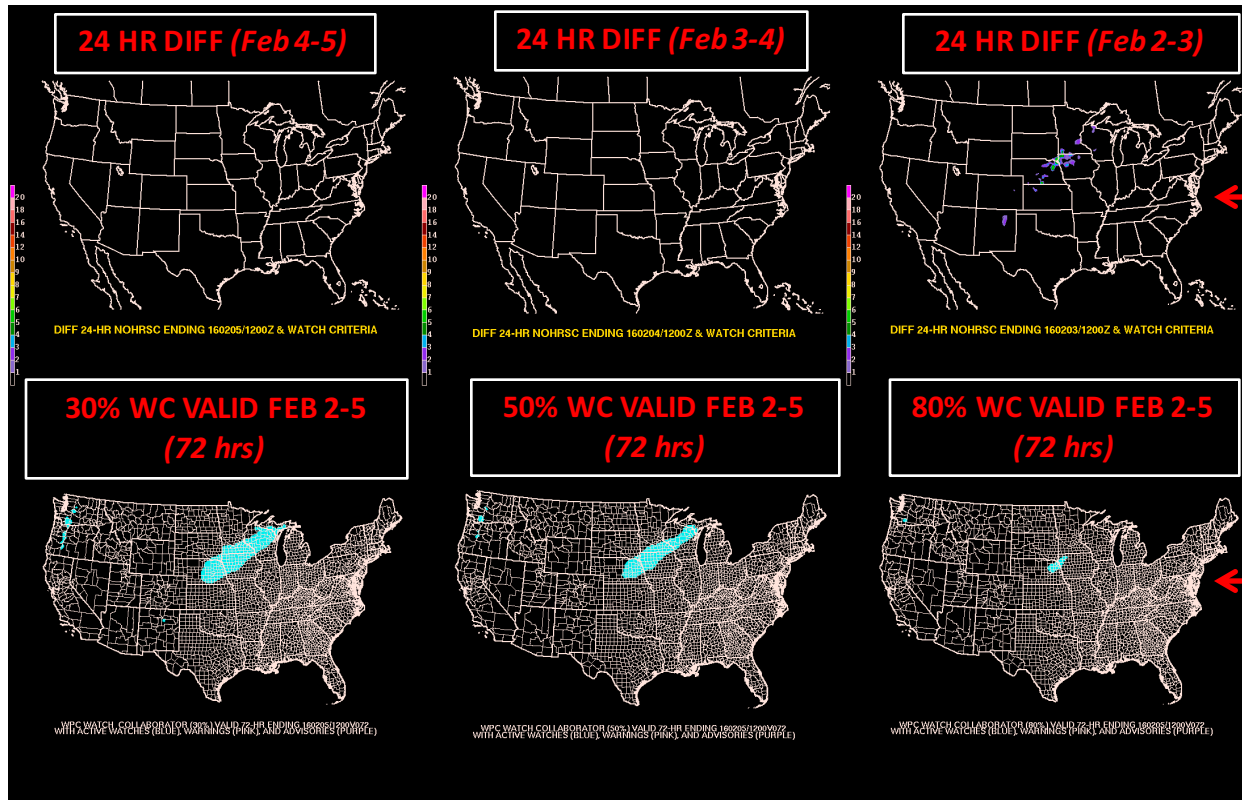


Ensemble Prob of Snow



Joint Prob of Melted Snow $> 0.25''$

Evaluation of the WPC Watch Collaborator (WC)



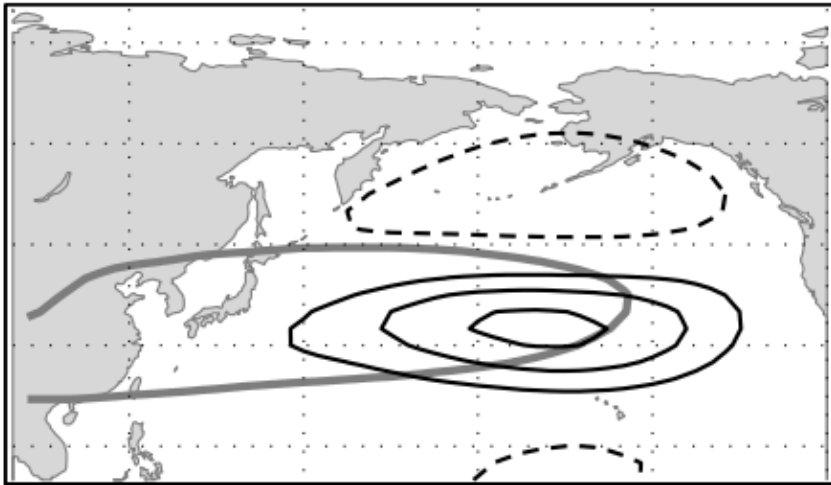
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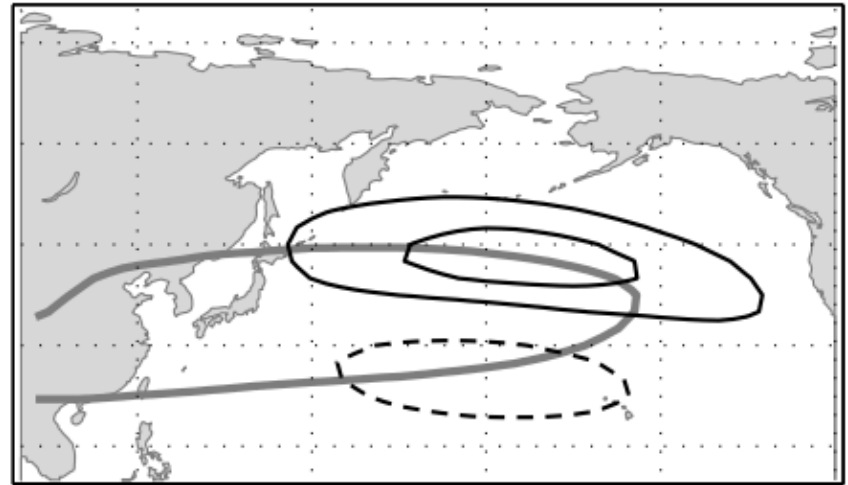
* Early in the experiment, the observed NOHRSC snowfall was used to evaluate the WC forecasts. The difference method was used the last 2 weeks to better highlight the varying watch snowfall thresholds.

Evaluation of 250-hPa Jet Displacements Using Principle Component Analysis

a. EOF 1 (Extend/Retract)



b. EOF 2 (Shift)



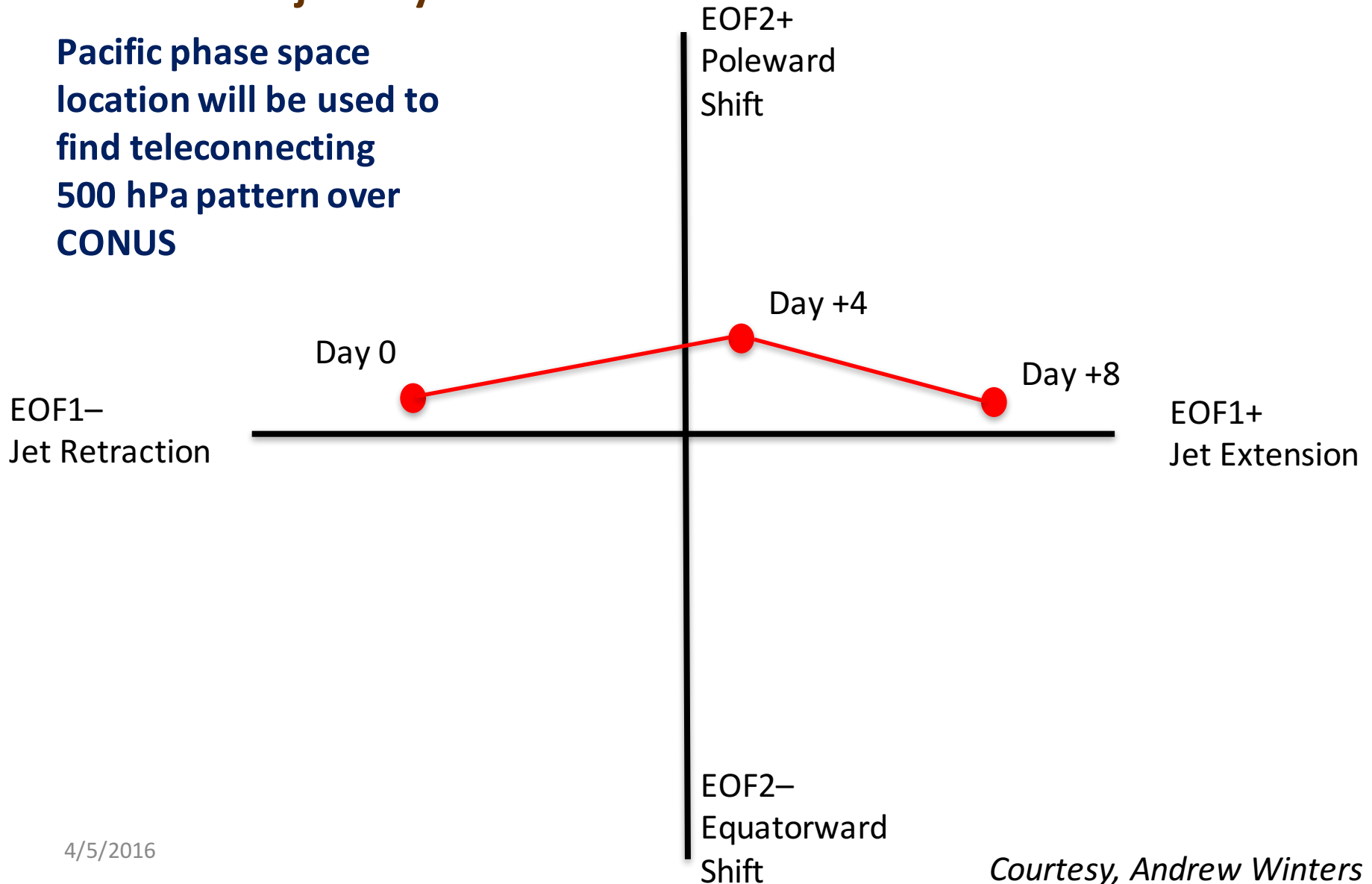
Jaffe 2012

- **Examine how antecedent environments project onto the leading EOF patterns associated with the 250-hPa N. Pacific Jet**
- **Both zonal and meridional displacements considered**

Phase Space Depiction Tool

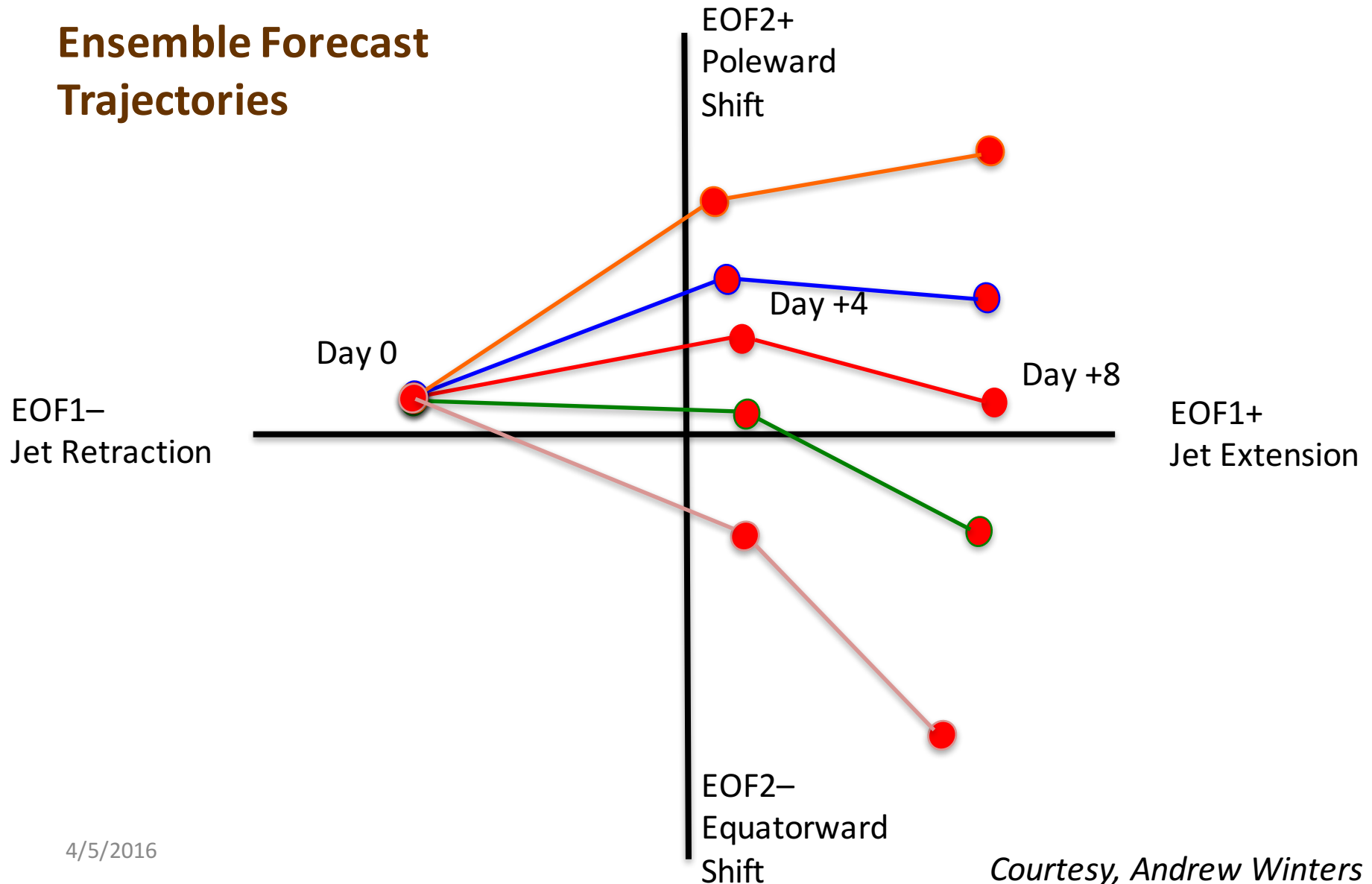
Forecast Trajectory

Pacific phase space location will be used to find teleconnecting 500 hPa pattern over CONUS



Phase Space Using Multi-Model or Ensemble Approach

Ensemble Forecast Trajectories



Extreme Weather Events (EWEs) at Day 8-10

Albany, NGGPS Round 1 R2O

